Wave Propagation, Surface-Roughness Parameterization and Wind Gustiness

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LONG-TERM GOALS

My research is directed toward understanding wave generation and wave motion in the ocean and in laboratory simulations thereof.

OBJECTIVES

See **LONG-TERM GOALS** above.

APPROACH

My primary approach is through mathematical models. Solutions ultimately are developed in both analytical and numerical form, but my goal is to obtain analytical results that inform phenomenological models for the prediction of physical events.

WORK COMPLETED

(Includes work completed in FY99 but published in FY00.)

[1] Miles, J. 1998: On gravity-wave scattering by non-secular changes in depth. *J. Fluid Mech.* **376**, 53-60.

[2] Miles, J. 1999: The quasi-laminar model for wind-to-wave energy transfer. Proceedings of the IMA Conference: *Wind-Over-Wave Couplings: Perspectives and Prospects*. (Eds Sajjadi, Hunt and Thomas), Oxford U. Press.

[3] Miles, J. 1999: On Faraday resonance of a viscous liquid. *J. Fluid Mech.* **395**, 321-325.

[4] Henderson, D. and Miles, J. 1999: Pinned-edge Faraday waves. *Fluid Dynamics at Interfaces* (Ed. W. Shyy), Cambridge University Press.

[5] Miles, J. (in press): A note on surface-wave scattering by a small plate. *Wave Motion*.

[6] Baines, P.G. and Miles, J. (in press): Topographic coupling of surface and internal tides. *Deep Sea Res.*

[7] Ierley, G. and Miles, J. (sub judice): On Townsend's model of the turbulent wind-wave problem. *J. Fluid Mech*.

[8] Miles, J. (sub judice): Stability of inviscid flow over a flexible boundary. *J. Fluid Mech.*

[9] Miles, J. (sub judice): Gravity waves on shear flows. *J. Fluid Mech*.

RESULTS

[1] deals with gravity-wave propagation and scattering in water of variable depth through a functional expansion in the departure of the depth from its flat-bottom mean.

[2] and [7] concern surface-wave generation by wind. [2] is an invited review dealing with my 1957 quasi-laminar model and its descendents.

[3] expresses the tri-diagonal determinant for Faraday resonance of a viscous liquid in terms of the surface-wave impedance and develops the result as a continued fraction to obtain a systematic sequence of analytical approximations for the threshold acceleration.

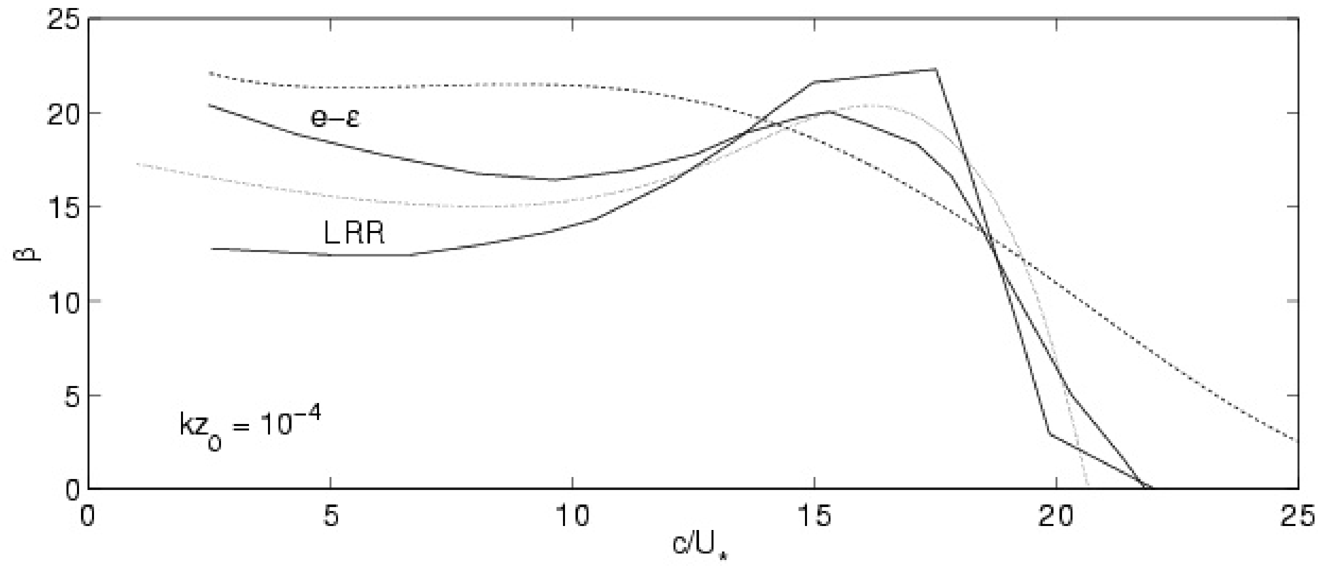
[4] considers surface waves on water in circular cylinders for which the contact line is fixed and the quiescent surface is flat and is aimed at improving our understanding of viscous and capillary-hysteresis damping. The theoretical predictions of natural frequencies and damping rates are confirmed experimentally except for the lowest axisymmetric mode, which requires further exploration.

[5] determines the scattering of gravity waves by a fixed plate (deck of zero draft).

[6] concerns the generation of internal tides through the interaction of surface tides with oceanic bottom topography taking into account the horizontal components of the Earth's rotation (as in my 1975 paper on Laplace's tidal equations), which have been neglected in most tidal calculations.

[7] revisits Townsend's (1980) model of wind-to-wave energy transfer, which is based on a putative interpolation between an inner, viscoelastic approximation and an outer, rapid-distortion approximation and predicts an energy transfer that is substantially larger than that predicted by my quasi-laminar model. It is shown that Townsend's (1980) predictions, although close to observation, rest on flawed analysis and numerical error. However, his (1972) model, after some corrections, yields results that are close to Mastenbroek's (1996) calculations.

[8] concerns the stability of an inviscid shear flow over an elastic plate (such as a ship's hull). The predicted threshold of absolute instability, as calculated through a boundary-layer approximation, differs from that calculated by Lingwood & Peake (1999) through numerical integration.



The wind-to-wave energy-transfer parameter β vs the dimensionless wave speed c/U* (U* is the friction velocity for the wind) with $kz_0 = 10^{-4}$ (k = wave number and z_0 = roughness length for the wind), as calculated for four different models: Miles's (1957) quasi-laminar model (- - -); Townsend's (1972) viscoelastic model (…); Mastenbroek's (1996) e-ε and LRR models (—).

[9] concerns gravity waves on a shear flow of finite depth (e.g., flow down an inclined plane). Complementary variational formulations that provide upper and lower bounds to the Froude number as a function of the wave speed and wave number are constructed.

IMPACT/APPLICATIONS

The results in [1], [5] and [9] are applicable to coastal engineering and naval operational problems. The results in [2] and [7] contribute to our understanding of air-sea interaction. The results in [3] and [4] are basic to our understanding of wave damping. The results in [6] contribute to our understanding of the balance of tidal energy in the oceans. The results in [8] are applicable to a wide range of problems, including naval architecture, panel flutter and blood flow.

TRANSITIONS

RELATED PROJECTS

PUBLICATIONS

See **WORK COMPLETED**.